# JOINT VENTURE (HSV-X1)

# LOAD PLANNING AND TRANSPORTABILITY ANALYSIS 16 SEPTEMBER 2002


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1. Background. The Joint Venture, HSV-X1, is a high-speed wave piercing sealift catamaran that was designed and built by the Australian shipbuilder, Incat Tasmania Pty Ltd. This vessel is being chartered under a two-year contract between a consortium of U.S. military services and Bollinger/Incat USA. The consortium is led by the U.S. Army's Tank-Automotive and Armament Command (TACOM), and includes the U.S. Navy, Coast Guard, Marine Corps and Special Operations Command. The services will use this craft to demonstrate its ability to perform specific mission scenarios, move troops, military vehicles and equipment.

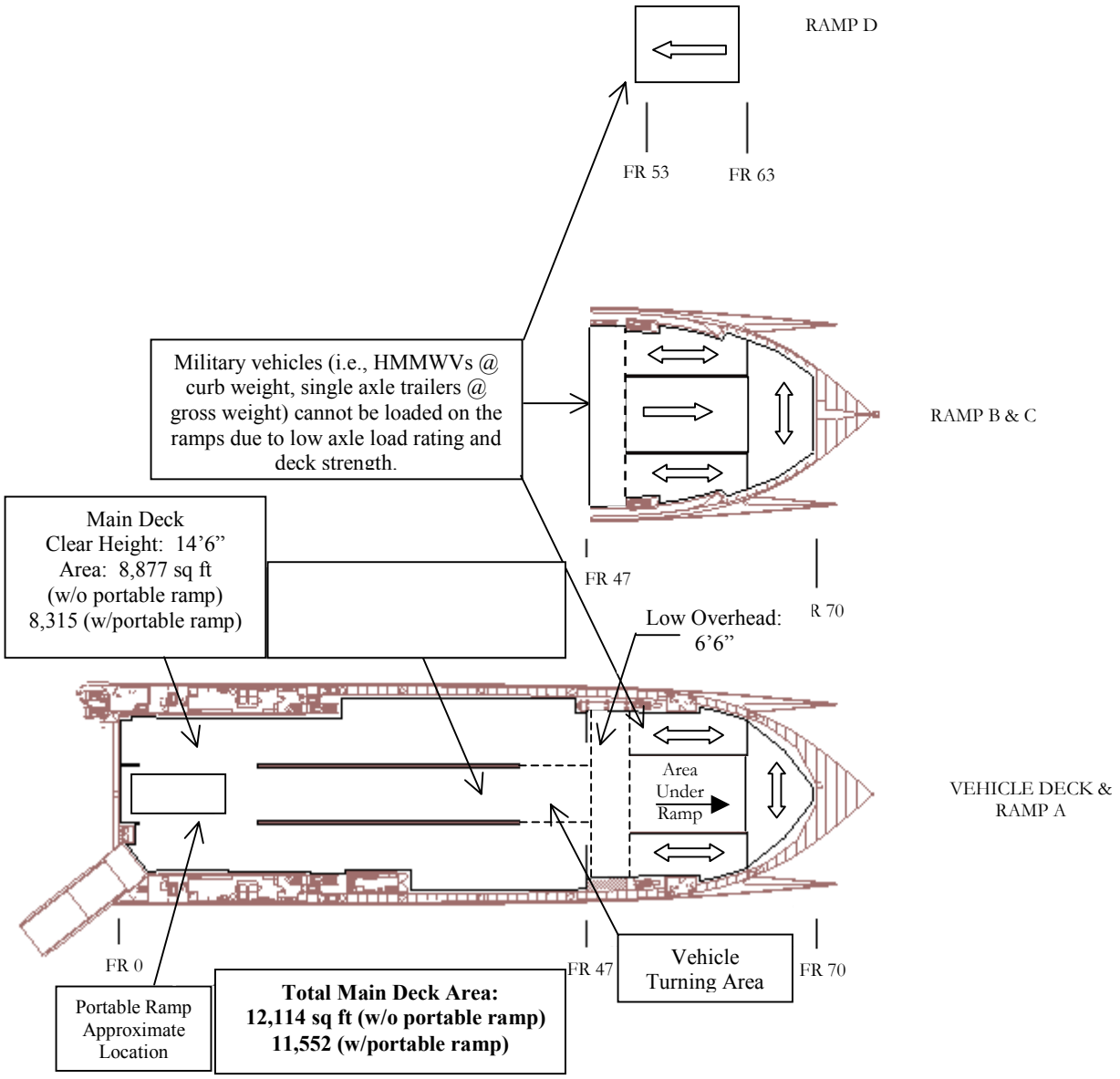
The Joint Venture underwent six weeks of technical and structural modifications that included the installation of a large helicopter deck; a two-part hydraulically operated stern quarter ramp, troop facilities, crew accommodations and a deployment gantry for rigid inflatable boats. Another portable exterior ramp was constructed and is stowed in the aft end of the vessel. This ramp allows for onload/offload of the vessel straight from the stern. The vessel's principal characteristics are:

Ship Type: High Speed Vessel – Experimental One (HSV-X1)
Hull Type: Wave Piercing Catamaran
Length: 313' (99.37 meters)
Beam: 87'4" (26 meters)
Draft, Maximum (Full Load): 13'0" (4 meters)
Displacement Tonnage (Full Load): 1,740 tonnes (1,918 ST)
Deadweight: 741 tonnes (815 ST)

The Navy and Army are giving the vessel a thorough workout. The Navy began preparing the Joint Venture in early October 01 and used it for various operations through February 02. The Army took control of the vessel in March 02 and used it in the CENTCOM region for current operations. In August 02, the Joint Venture participated in Millennium Challenge 02 and was loaded with the new Infantry Carrier Vehicles (ICVs) that are part of the Stryker Family of Vehicles. These vehicles were loaded on the vessel on 11 August 2002 at Port Hueneme, CA, and transported approximately 1200 nautical miles to the Port of Tacoma, WA.

MTMCTEA is working with TACOM in analyzing the transportability of the Stryker Family of Vehicles and other military equipment aboard the Joint Venture. Our findings are documented below:

a. Cargo Area: The militarily useful cargo area of the HSV-X1 is 12,114 square feet or if the new portable ramp is stowed on the main deck of the vessel this cargo area decreases by 562 square feet to 11,552 square feet. The diagram (figure 1) below shows all of the deck areas for this vessel. Only the main deck and area under the hoistable mezzanine vehicle deck can be used to load vehicles. The ramp areas could be used for palletized equipment or other small items.




Cargo stow area in the main deck aft section is limited due to the stowage of a recently built portable ramp that is stowed here - 562 square feet (39.4'long x 15.58'wide x 4.2" high) with a weight of 7.39 STON (14,771 lbs).

Figure 1: HSV-X1 Deck Layout

b. Capacity: The deadweight of the HSV-X1 is 815 short tons (ST). Deadweight is the total lifting capacity of the vessel. It includes the weight of the cargo, fuel, water, passengers, baggage, and the crew and their effects. There is no set cargo carrying capacity for this vessel as it is dependent on the weights of the amount of fuel, passengers, baggage, crew, and water that will be carried for each voyage. Table 1 shows the payload for ranges of 800, 1250 and 2400 nautical miles:

TABLE 1: PAYLOAD VERSUS RANGE

| Items of Vessel Deadweight Excluding Cargo | | | | | Total for Items of Vessel Dead-Weight (STON) | Total Cargo Payload (815 ST Minus Items of Vessel Dead-weight) | Distance in Nautical Miles @ Stated Fuel Capacity |
|---|---|---|---|---|---|---|---|
| Crew/Effects, Fresh Water, Misc Stores/ Provisions (STON) | No.Pax/ Weight (STON) Pax Wt = .15 STON each | No. Drivers/Weight (STON) Driver Wt = .15 STON each | Fuel w/25% Reserve (STON) | Lube Oil (STON) | | | |
| 20.2 | 0/0 | 13/2.1 | 162 | 1 | 185.5 | 629.5 | 800 |
| 20.2 | 325/47 | 13/2.1 | 162 | 1 | 232.5 | 582.5 | 800 |
| 20.2 | 0/0 | 13/2.1 | 258.6 | 1 | 281 | 534 | 1250 |
| 20.2 | 325/47 | 13/2.1 | 258.6 | 1 | 328 | 487 | 1250 |
| 20.2 | 0/0 | 13/2.1 | 375 | 1 | 398.3 | 416.7 | 2400 |
| 20.2 | 325/47 | 13/2.1 | 375 | 1 | 445.3 | 369.7 | 2400 |

c. Draft, Trim and Stability: MTMCTEA used the Integrated Computerized Deployment System (ICODES) to analyze the loading capability of the HSV-X1 with various types of cargo (Infantry Carrier Vehicles, HMMWVs, HEMTTs, trailers, family of medium tactical vehicles, etc.). ICODES is the US Transportation Command's stowplanning system for all of the military services. The following definitions for draft, trim and stability are given to provide a better understanding of ship loading terminology. Draft is the depth of the vessel below the waterline, measured vertically to the lowest part of the hull, or other reference point. Trim is the difference between the draft forward and the draft aft. Stability is the tendency of the vessel to remain upright or the ability to return to her normal upright position when heeled by the action of waves, wind, etc. The full load draft for the HSV-X1 is approximately 13 feet.

(1) Placement of cargo to meet the draft, trim and stability requirements is the greatest challenge in loading this vessel. Heavy equipment needs to be placed in the midship's forward area aft of Frame 47. This seems to be the critical area for keeping the draft of the ship at an even keel. Adding cargo in the aft area caused various

changes in the draft and trim requirements of the vessel to the point where cargo had to be continuously moved to meet the requirement. Since the vessel's fuel tanks are located in the aft section (port and starboard), the amount of fuel in the tanks (weight) will have an impact on the trim and stability of the vessel and the cargo that can be stowed here.

(2) Most military equipment cannot be stowed in the forward ramp areas (forward of Frame 47) due to deck stress and axle load violations. Breakbulk and palletized items could be stowed here but this would require an on-board forklift to load/offload. If heavier items could be stowed here, it would be easier to maintain an even keel on the vessel since most of the heavy equipment is stowed in the middle and aft area to include the loaded fuel tanks in the aft.

d. Axle Load and Deck Stress: ICODES bases its deck loading on the pounds per square foot (PSF) of the cargo shadow area. Instead of using the ICODES PSF deck loading criteria, MTMCTEA used the axle load ratings as posted on the Incat Vehicle Deck Loading signage for the HSV-X1 (96M Wave Piercing Catarmaran Ferry). Using the vessel's axle load ratings in lieu of the PSF enabled us to better analyze the loading strength of the deck. We found that the axle load rating for the vessel limits the type of military cargo that can be stowed as follows:

(1) Forward Ramps: The max axle load rating on all forward ramps is .8 tonnes (.88 STON) forward of Frame 47. This low axle load rating precludes the loading of most military vehicles (i.e., HMMWVs – M998 and M1113 series, and loaded single-axle trailers (M101, M1101, M1102, etc)).

(2) Main Deck Area (aft of FR 47): The axle load ratings in this area vary depending on the maximum number of axles or axle group loads and tire widths. These vehicles were found to exceed the vessels' axle load ratings:

(a) HEMTT-LHS: HSV-X1 Max Axle Group Load (tonnes) for Tandem (4 tires) – **13.3 tonnes** with tire width from 375 mm minimum to less than 450 mm. The HEMTT-LHS fits into the tandem 4 tires @ 444.5 mm tire width (17.5" per tire) category. The gross weight of the HEMTT-LHS is:

- Front tandem pair: 26,352 lbs (11.95 tonnes)
- Rear tandem pair: 36,588 lbs (**16.59 tonnes**) (exceeds HSV-X1 tandem 4 tire group by **7,254.45 lbs (3.29 tonnes)**

(b) Stryker (IAV): HSV-X1 Max Axle Group Load (tonnes) for Quad 8 tires – **15 tonnes** (33,075 lbs for an axle group with a tire width of less than **375 mm**). The Stryker family of vehicles fits the quad (8 tires) category with a tire width of less than 375mm (Stryker tire width – 339 mm or 13.3"). The axle load as provided in the initial transportability reports for these vehicles is shown in Table 2 below:

TABLE 2. STRYKER AXLE LOAD RATINGS

| Model | Empty Weight (lbs) | Exceeds HSV-X1 Rating by (lbs): | Gross Weight (lbs) | Exceeds HSV-X1 Rating by (lbs): |
|---|---|---|---|---|
| ICV Rifle Carrier | 31970 | - | 43200 | **10125** |
| ICV Wpns Carrier | 31970 | - | 43200 | **10125** |
| Anti-Tank Guided Missile (ATGM) | 34654 | **1579** | 43200 | **10125** |
| Command Vehicle (CV) | 32526 | - | 43200 | **10125** |
| Engineer Support Vehicle (ESV) | 32220 | - | 43200 | **10125** |
| Fire Support Vehicle (FSV) | 32204 | - | 43200 | **10125** |
| Mortar Carrier (MC) | 34146 | **1071** | 43200 | **10125** |
| Medical Evaluation Veh (MEV) | 32162 | - | 43200 | **10125** |
| NBC Recon Veh (NBC RV) | 33974 | **899** | 43200 | **10125** |
| Recon Veh (RV) | 32220 | - | 43200 | **10125** |
| Mobile Gun System (MGS) | 38638 | **5563** | 43200 | **10125** |

(c) MTMCTEA provided TACOM, CASCOM, and INCAT with detailed data on these axle load ratings for review. INCAT verbally stated that they would allow the Strykers and HEMTT-LHS to be loaded on the HSV-X1. However, CASCOM and TACOM requested that INCAT obtain Det Norske Veritas (DNV) certification for loading these vehicles on the vessel. DNV is an international certification organization. INCAT complied with this request. DNV issued an Appendix to the INCAT Classification Certificate that approved the loading of all Stryker variants at gross weight and the HEMTTs and PLS were approved to be loaded at empty weight (without a payload).

(d) These are just a few examples of the vehicles that we found that exceed the HSV-X1 main deck maximum axle or axle group load rating. There are other military vehicles that could exceed these ratings. MTMCTEA can evaluate additional vehicles as required.

e. Tiedowns and Lashing Gear: Car ferries normally are not required to tie vehicles down because they carry only light cargo, travel a short distance, and go through calm seas. Using this type of vessel to carry heavy-duty military equipment at longer distances and heavier sea states will require this equipment to be tied down to prevent damage to the vehicles and the vessel.

(1) Tiedowns: Approximately 39 Peck and Hale cloverleafs (Figure 1) were added to the vessel's main deck @ 6.5 tons each and spaced 27.5 feet longitudinally and 10' laterally apart. Original vessel tiedown tubes (Figure 2) are for .8 tonne (1,764 lbs) axle load cars only. Figure 3 shows the main deck with the cloverleafs and tiedown tubes.

Figure 2. Peck and Hale Cloverleaf (New)

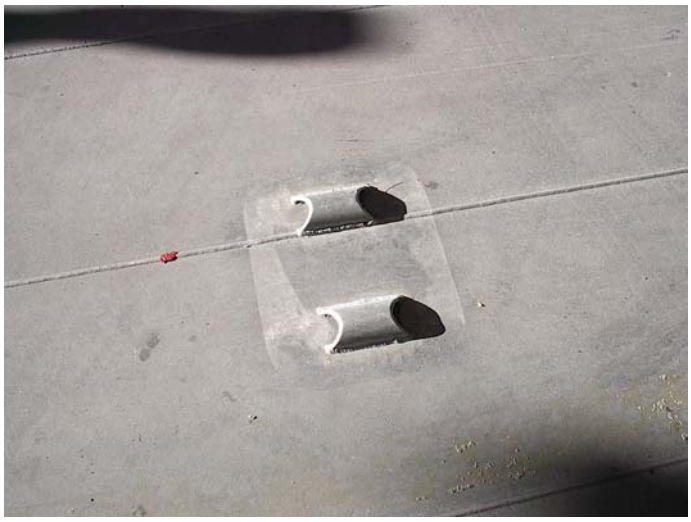


Figure 3. Original Vessel Tiedown Tube
.8 Tonne Axle Rating

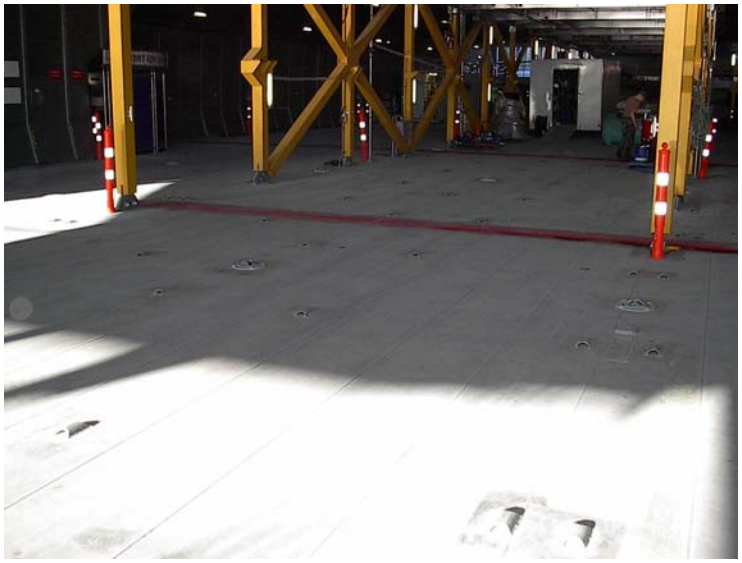


Figure 4. View of Tiedown Tubes and
Peck and Hale Cloverleafs on Main Deck

(2) Lashing: 100 – 1 ton cargo straps; 100 – 2.5 ton cargo straps; 60 – 3500 lb Peck & Hale chain gripes; 150 – 8500 lb Peck & Hale chain gripes.

(3) Recommended lashing requirements for tracked/wheeled vehicles and trailers per MTMCTEA Pam 55-22, Marine Lifting and Lashing Handbook are:

| Vehicle weight (lbs) | Lashing Strength | Number of Lashings Required |
|---|---|---|
| Up to 8,930 | 5,000 lb | 4 |
| Up to 17,860 | 10,000 lb | 4 |
| Up to 23,180 | 14,100 lb | 4 |
| Up to 30,360 | 17,000 lb | 4 |
| Up to 65,510 | 35,000 lb | 4 |
| Up to 125,020 | 70,000 lb | 4 |
| Up to 250,000 | 70,000 lb | 8 |

Polyester straps should be used for tying down helicopters on this vessel. The following guidance is provided for procurement of these straps:

| Helicopter | Type Strap (standard or wide ratchet) | Breaking Strength (lbs) | End Hardware | No. Required Per Helo |
|---|---|---|---|---|
| UH-60 | 3” Ratchet | 15,000 | Wire Hook | 8 |
| AH-64 | 2” Ratchet | 10,000 | Wire Hook | 10 |
| OH-58 | 2” Ratchet | 5,000 or 6,000 | Wire Hook | 10 |
| CH-47 | 3” Ratchet | 15,000 | Wire Hook | 18 |
| UH-1 | 2” Ratchet | 10,000 | Wire Hook | 9 |

f. Maneuvering: Vehicles enter from the stern on a hydraulically operated vehicle ramp located on the starboard side. Vehicles can be loaded on this vessel in a variety of ways:

- Drive up the ramp to the port side and travel in a horseshoe pattern around the hoistable deck supports to the starboard side.
- Back up the ramp and back into stowed position.
- Drive up the ramp and turn in the aft area to back into the area under the hoistable deck or along the sides.
- Drive straight in or back in via the portable vehicle ramp.

(1) Since the aft end of the vessel is 62'4" wide, the max vehicle turning radius in the aft end would be 30'4" (allows for a 1' clearance between vehicle and each wall). The width of the forward turning area is 78' with a vehicle turning radius of 38' (allows for a 1' clearance between vehicle and each wall) in the horseshoe turn area aft of FR 47. The turning radius of some of the legacy force vehicles such as the M939 series 5-ton trucks exceed the turning radius of the HSV-X1 (see Table 3). Maneuvering truck/trailer combinations inside this vessel may be very difficult depending on the type of trucks and trailers loaded. There shouldn't be any problems loading HMMWVs with trailers but larger combinations such as the M1083A1/M1095A1 (FMTV) may need to be backed onto the vessel or maneuvered several times inside the vessel.

(2) Horseshoe Turning Area: The following illustrations show how various types of vehicles would maneuver in the horseshoe turning area and other parts of this vessel. When vehicles are loaded using the horseshoe pattern, adequate space should be left in the area around FR 47 to allow for vehicle maneuvering and stowage.

- Figure 5. Sample Load Plan Showing Vehicles Loaded Using Horseshoe Turning Area
- Figure 6. Sample Load Plan Showing All Vehicles Backed In
- Figure 7. Stryker Maneuvering on Main Deck
- Figure 8. M923A2 Maneuvering on Main Deck
- Figure 9. HEMTT Maneuvering on Main Deck

**Sample Vehicle Load Plan**
**Vehicles Driven Through Horseshoe**
**Turning Area Into Stow Location**

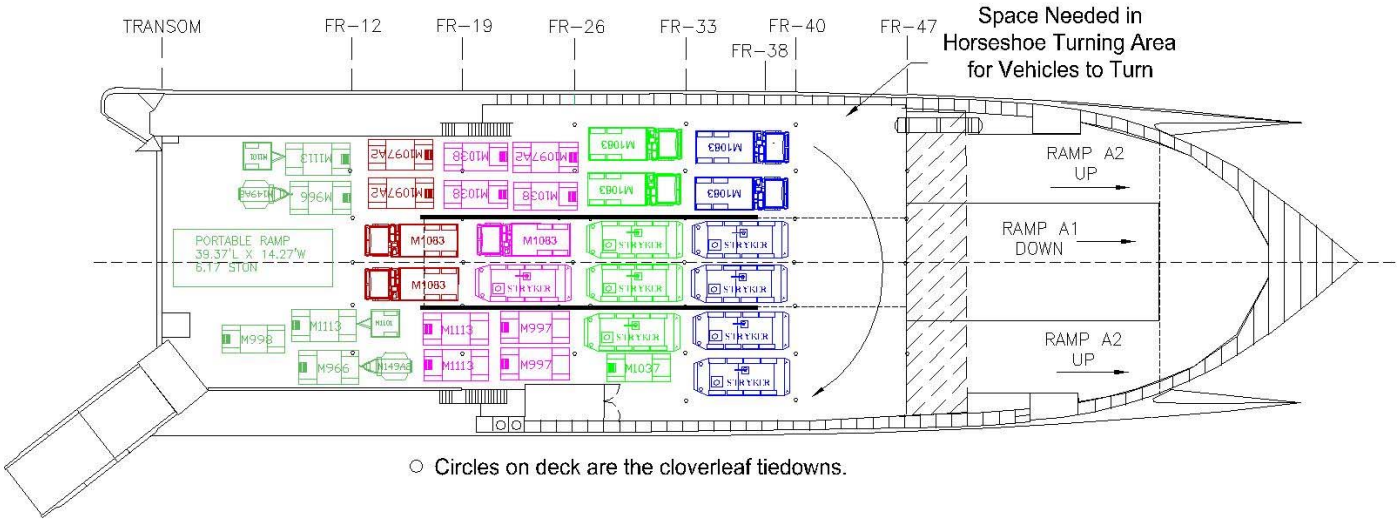



Figure 5. Sample Load Plan Showing Vehicles Loaded
Using Horseshoe Turning Area

**Sample Vehicle Load Plan**
**Horseshoe Turning Area Not Used**
**All Vehicles Backed In**

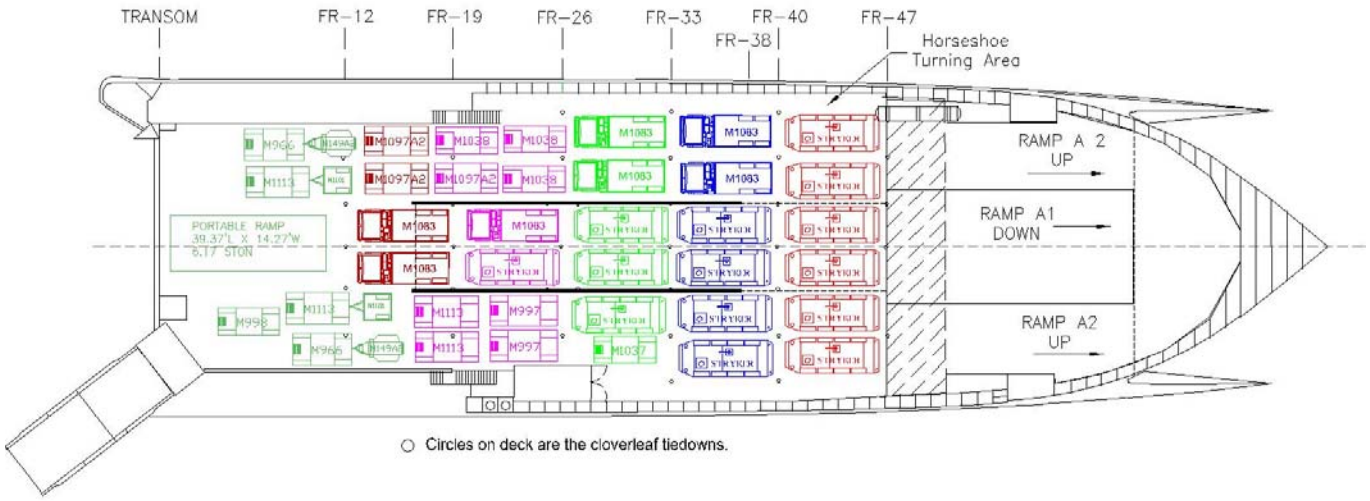



Figure 6. Sample Load Plan Showing All Vehicles Backed In

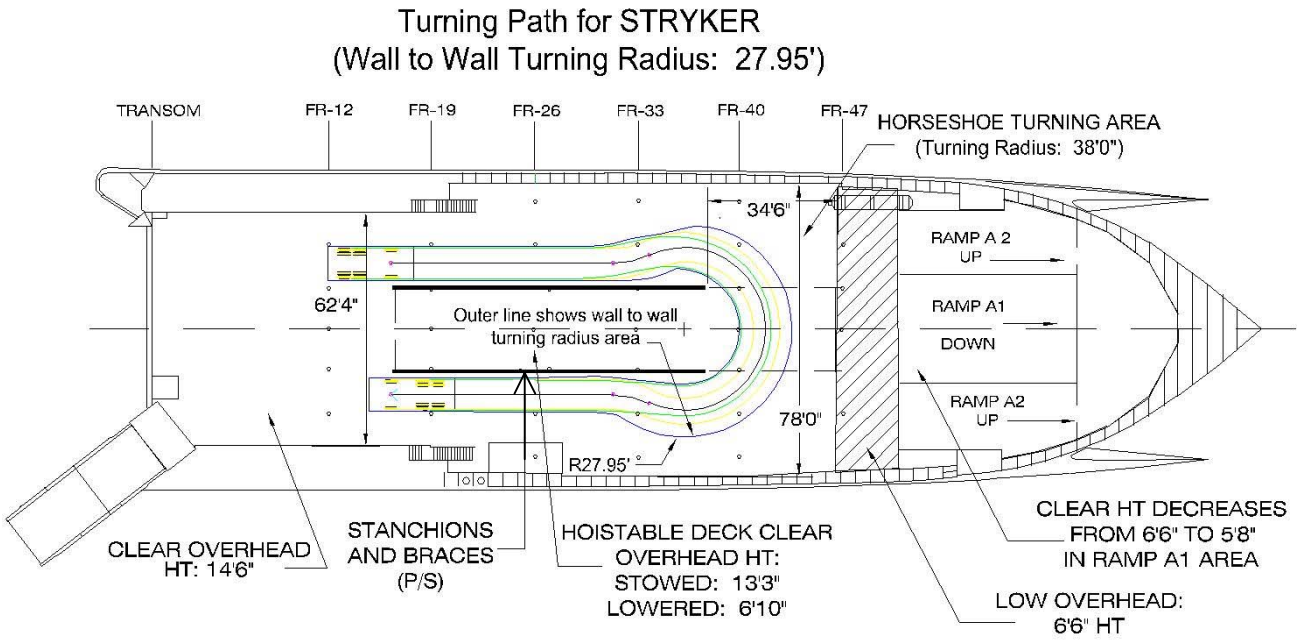



Figure 7. Stryker Maneuvering on Main Deck

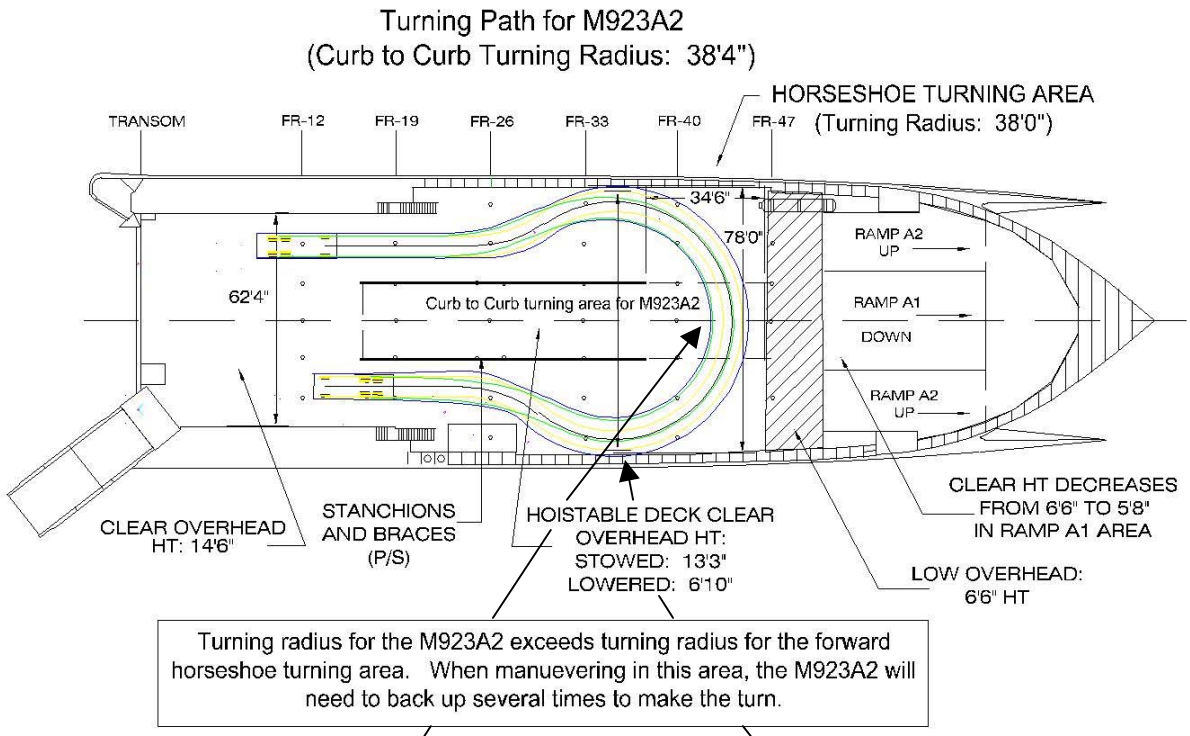



Figure 8. M923A2 Maneuvering on Main Deck

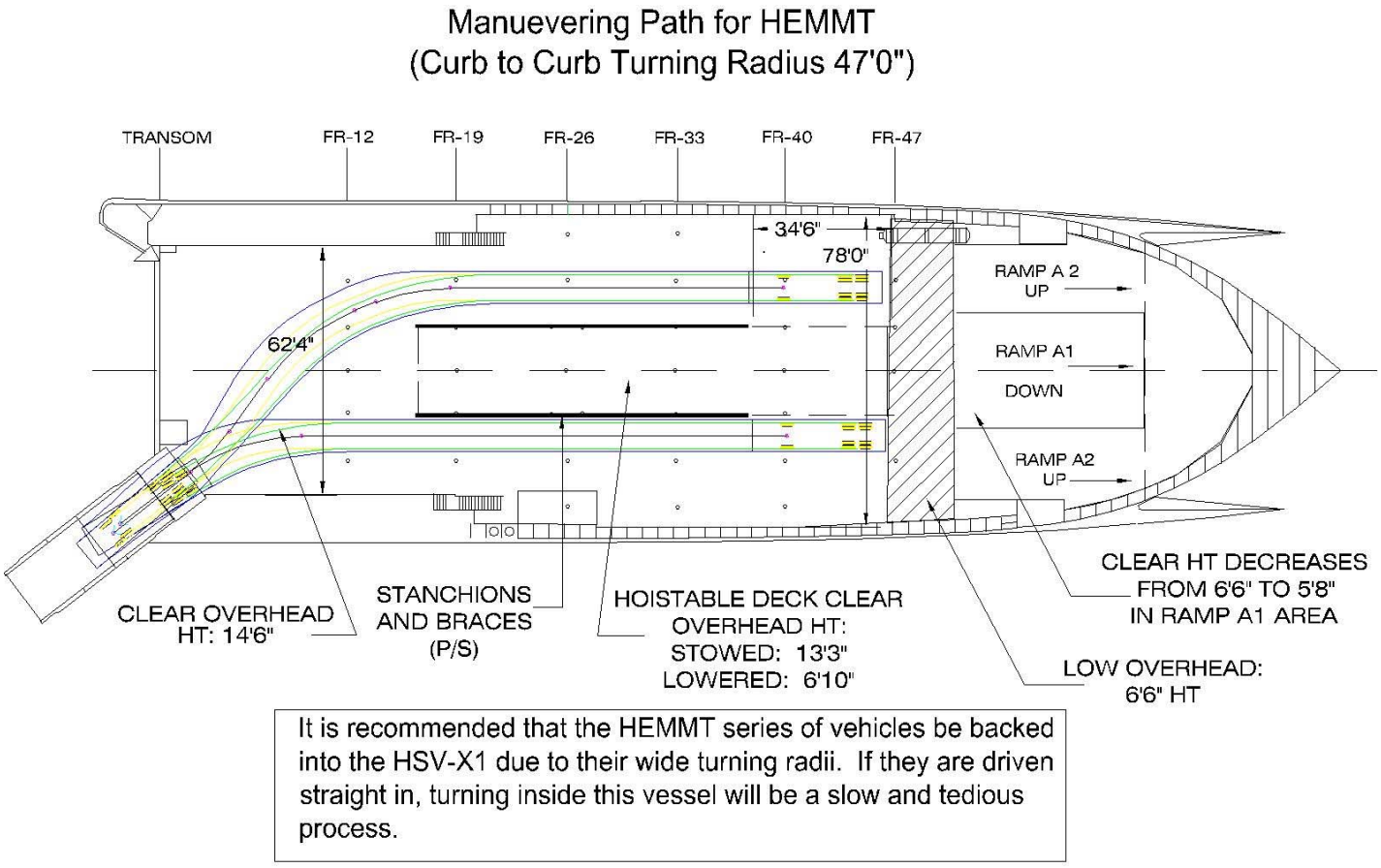



Figure 9. HEMTT Maneuvering on Main Deck

Table 3. Turning Radii of a Select Group of Military Vehicles

| Model | Description | Vehicle Turning Radius | Exceeds HSV-X1 Fwd Area Turning Radius (38') |
|---|---|---|---|
| Stryker | Infantry Carrier | 27'11"[1] | |
| M998 | HMMWV | 24'4"[2] | |
| M977/M978/M985 | HEMTT | 47'0"[2] | X |
| M1074/M1075 | PLS | 60'0"[1] | X |
| M1070 | HET | 37'0"[1] | |
| M1078A1/M1079A1/ M1080A1 | FMTV 2.5 TON | 27'11"[1] | |
| M1083A1/M1088A1/ M1090A1/ M1092A1 | FMTV 5 TON | 30'9"[1] | |
| M1084A1/M1096A1/ M1085A1 | FMTV 5 TON | 36'0"[1] | |
| M1089A1/ | FMTV 5 TON | 40'6"[1] | X |
| M1086A1/M1087A1 | FMTV 5 TON | 42'6"[1] | X |
| LAV III | Armored Pers Carrier | 27'11"[1] | |
| M923/M925/A1 | M939 Series 5 Ton Trk | 38'0"[2] | X |
| M929/M930 | M939 Series 5 Ton Trk | 39'3"[2] | X |
| M929A1/M930A1 | M939 Series 5 Ton Trk | 36'8"[2] | |
| M931/M932/A1 | M939 Series 5 Ton Trk Trac | 39'3"[2] | X |
| M934 | M939 Series 5 Ton Trk Van | 47'3"[2] | X |
| M934A1 | M939 Series 5 Ton Trk Van | 45'3"[2] | X |
| M935/A1 | M939 Series 5 Ton Trk Van | 45'3"[2] | X |
| M936/A1 | M939 Series 5 Ton Trk Wrecker | 39'0"[2] | X |
| M923A2 | M939 Series 5 Ton Trk | 38'4"[2] | X |
| M925A2 | M939 Series 5 Ton Trk | 42'10"[2] | X |
| M927A2/M928A2 | M939 Series 5 Ton Trk | 47'6"[2] | X |
| M929A2/M930A2 | M939 Series 5 Ton Trk | 38'4"[2] | X |
| M931A2/M932A2 | M939 Series 5 Ton Trk Trac | 39'3"[2] | X |
| M934A2 | M939 Series 5 Ton Trk Van | 47'3"[2] | X |
| M936A2 | M939 Series 5 Ton Trk Wrecker | 42'10"[2] | X |
| [1]Wall-to-Wall Turning Radius | | | |
| [2]Curb-to-Curb Turning Radius | | | |

Vehicles that exceed the HSV-X1 turning radius can be loaded in several ways: 1) back up the ramp into the vessel and maneuver to the designated stow position (see HEMTT loading diagram); 2) drive straight up the ramp, maneuver the vehicle in the aft area and back into stow area, (3) back up the portable ramp and turn in the aft area to maneuver into stow location or drive straight up the portable ramp, maneuver around in the aft area to designated stow location. The process of loading vehicles by backing up the ramp increases loading time but decreases offloading time as vehicles are positioned for ease of offload. The illustration (Figure 10) below shows how a 5-ton truck could drive up the ramp into the vessel's aft area and maneuver to the designated stow location.

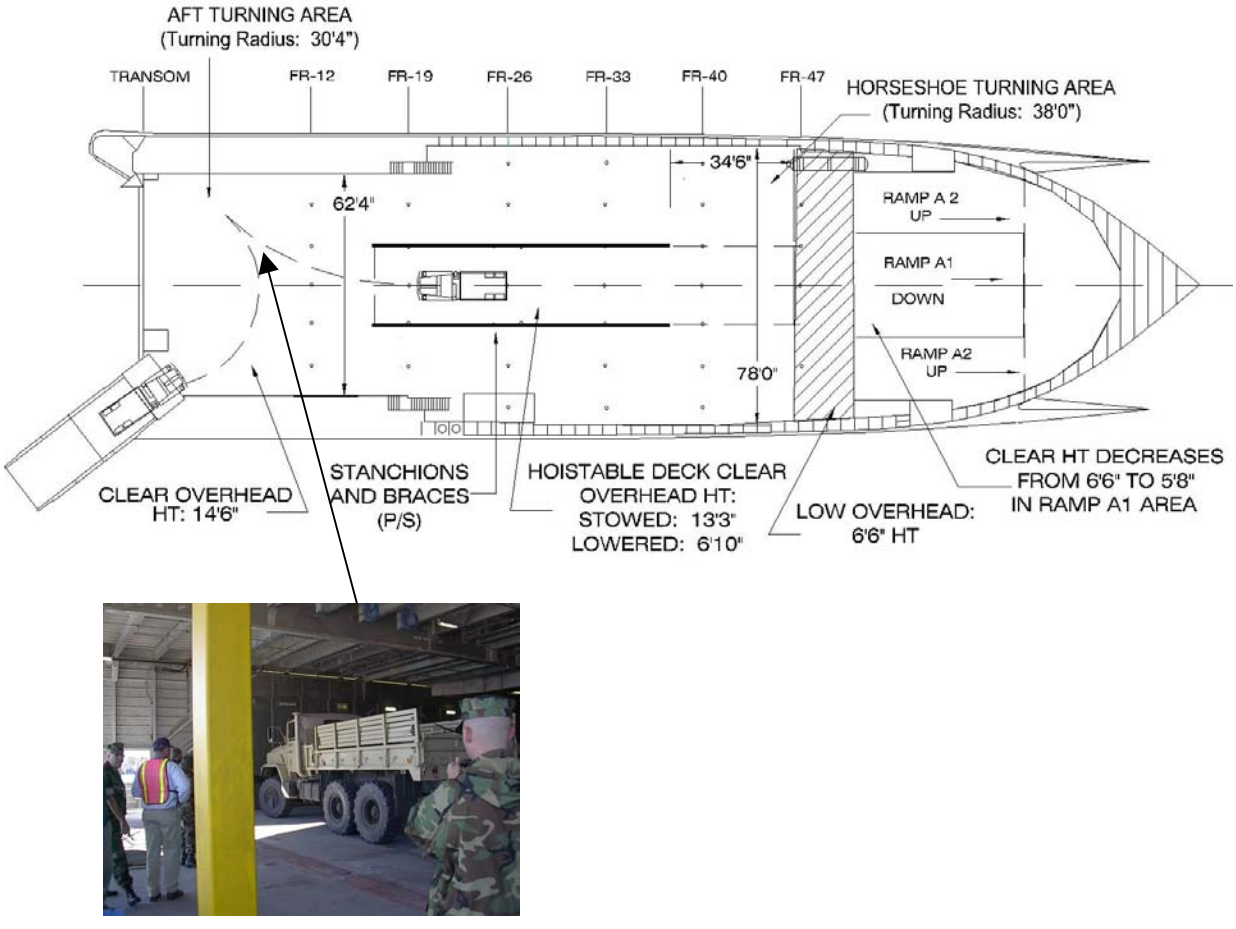



Figure 10. 5-Ton Truck Maneuvering Diagram

g. Main Deck Stowage Limitations:

(1) The hoistable deck stanchions and braces, located in the center of the deck, cause many problems in cargo stowage and maneuvering. If these could be removed, it would increase the amount of cargo that could be stowed and simplify the stowplanning process. Also, vehicles would not have to maneuver around these stanchions and loading time would decrease.

(2) Flex Joints: Vehicle wheels cannot be placed directly on the flex joints that are designated by red lines on the deck as shown in Figure 11. These flex joints create another limitation in cargo stowage and may decrease the amount of cargo that can be stowed.

Figure 11. Flex Joints on Main Deck

(3) Ship's Gear: Ship's gear on this vessel should be located in areas other than the cargo stowage area on the main deck. Figure 11 shows two containers with ship's gear that are positioned in the cargo stowage area. Figure 12 shows additional gear that is stowed in the cargo stowage area. This equipment takes up valuable cargo space and decreases the vehicle maneuvering capabilities even more.

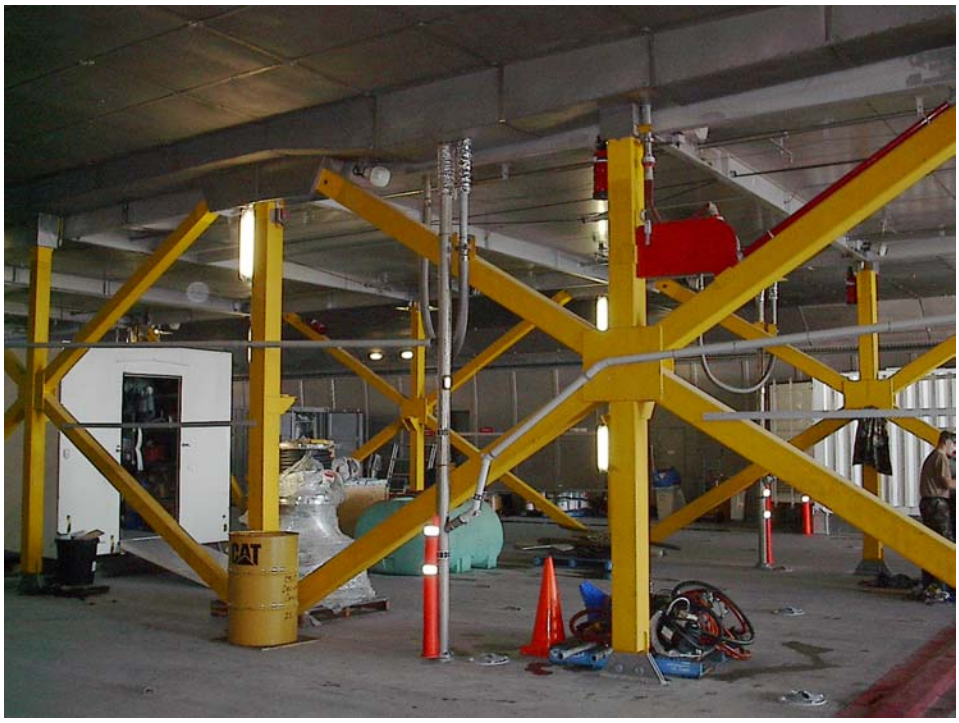


Figure 12. Ship's Gear in Cargo Area

h. External Ramps: The HSV-X1 has two ramps:

(1) A hydraulically operated hinged, stern quartering ramp is located on the starboard rear quarter of this vessel (see Figure 13). It has a capacity of 77,175 lbs (35 metric tons) and is 14'4" wide. When the ramp is deployed, the center, hinged area is affected by tidal variations (see Figure 14). This hinged area can be adjusted hydraulically to compensate for these variations. These adjustments sometimes cause a steep angle of entry for cargo and spanners are used to lesson the angle (see Figure 15). The fluctuation of the ramp may cause truck/trailer combinations and other types of towed equipment to bottom out depending on the position of the ramp at various tides. The angle could also cause forklifts (with palletized cargo) transiting through this area to topple or go off balance. Loading at high tide creates a straight stern quartering ramp (see Figure 16) thereby eliminating the need for the spanners and easing the loading of the equipment on the ramp.

Figure 13. Stern Quartering Ramp

Figure 14. Crest at Center Hinge at Low Tide

Figure 15. Wooden Spanners

Figure 16. Ramp at High Tide

(2) Portable Ramp: A portable stern ramp (figure 17) was added to the vessel to ease loading of helicopters and eliminate the loading limitations encountered on the quarter stern ramp. This ramp is 39'4" long x 14'3" wide (between structure) or 15.58' overall width and 4.2' high. The fingers are 8'6" long X 1'9" wide. The ramp weighs 7.39 STON (14,771 lbs) with a safe working load capacity of 77,175 lbs (35 metric tons).

Figure 17. Portable Stern Ramp With Fingers

i. Materiel Handling Equipment (MHE). The vessel has the following MHE:

(1) Single hydraulic pallet jack, 5000 lbs capacity.
(2) Fixed hoist, in the center aft area, rated at 22,050 lbs (10 metric tons). See figure 14 (top center).

2. Summary: The Joint Venture (HSV-X1) in its present configuration has proven it can support the Army and Marine Corps in worldwide operations. However, it has loading limitations that affect several types of cargo items to include helicopters, truck-trailer combinations, and vehicles with four or more axles. The following items should be considered for transportability and deployment of cargo for the Theater Support Vessel (TSV) program:

- ICODES uses PSF to calculate deck stress which is the preferred way to determine deck loading criteria for ships. However, these high speed vessels have aluminum decks that are more characteristic of an aircraft where axle loads are the

primary criteria for structural loading. MTMCTEA had access to pertinent vessel and equipment data to determine the vehicle axle loads versus the vessel axle load rating. The marine cargo specialists who load these vessels may not have access to the vehicle axle loads and the vessel's Vehicle Deck Loading signage. If the high speed vessels will be loaded by marine cargo specialists, then the deck loading criteria in ICODES should be programmed to have the vessel's Vehicle Deck Loading signage and vehicle axle loads.

- The main deck area should be open with few obstructions, i.e., center supports and beams. Ship's gear should be stowed outside of the vessel's cargo stowage area. If ship's gear is permanently located in the cargo stowage area, it should be placed in an area where it does not interfere with vehicle maneuvering. The square footage of the ship's gear should not be counted as cargo stow area.

- The vessel should have an onboard forklift (6K) to move breakbulk/palletized equipment, small trailers, small helicopters, etc.

- The ramp should be located in the center of the vessel to preclude unnecessary vehicle maneuvering from the side. It should be a straight stern ramp with a ramp angle limited to 12 degrees down. Angle should be measured from the top of the platform to the ramp driveway. There should be no joints/knuckles in the ramp and it should be American Bureau of Shipping (ABS) rated to carry the heaviest cargo and widest item that will be loaded on the vessel.

- Cargo securing fittings should be flush ¾-inch cloverleaf sockets. These sockets should be arranged on approximate 4-foot by 4-foot centers. The grid should start approximately 1.5 feet from the interior skin of the vessel.

- Vehicle Lashing Assemblies (VLA) should be Peck and Hale 17,000 and 35,000 pound rating. VLAs should be marked with the rating. They should be chain type, complete with quick-release tensioners on the chain end and bulb hook on the tensioner end. Polyester straps should be procured in accordance with MTMC guidance for movement of helicopters. VLA and polyester strap stowage area should be provided outside of the cargo stow area.

- Vehicle deck strength should be rated to carry the heaviest cargo item to be loaded on the vessel. The deck should be free of restrictions such as the plate covers over the joints on the HSV-X1 where wheels cannot be stowed directly on these joints.

3. MTMCTEA POC's for the HSV-X1 are Ms. Terry DeLucia,, (757) 599-1669, deluciat@tea-emh1.army.mil or Mr. John Atwood, (757) 599-1648, atwoodj@tea-emh1.army.mil.